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Construction Engineering Research Laboratory

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Engineer Research and Development Center

Site Evaluation for Application of Fuel Cell Technology

911th Airlift Wing, Pittsburgh, PA

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Foreword

In fiscal years 93 and 94, Congress provided funds for natural gas utilization equipment, part of which was specifically designated for procurement of natural gas fuel cells for power generation at military installations. The purchase, installation, and ongoing monitoring of 30 fuel cells provided by these appropriations has come to be known as the "DOD Fuel Cell Demonstration Program." Additional funding was provided by: the Office of the Deputy Under Secretary of Defense for Industrial Affairs & Installations, ODUSD (IA&I)/HE&E; the Strategic Environmental Research & Development Program (SERDP); the Assistant Chief of Staff for Installation Management (ACSIM); the U.S. Army Center for Public Works (CPW); the Naval Facilities Engineering Service Center (NFESC); and Headquarters (HQ), Air Force Civil Engineer Support Agency (AFCESA).

This report documents work done at 911th Airlift Wing, Pittsburgh, PA. Special thanks is owed to the 911th Airlift Wing point of contact (POC), Bruce Foster and Jim Perlik, for providing investigators with access to needed information for this work. The work was performed by the Energy Branch (CF-E), of the Facilities Division (CF), Construction Engineering Research Laboratory (CERL). The CERL Principal Investigator was Michael J. Binder. Part of this work was performed by Science Applications International Corp. (SAIC), under Contract DACA88-94-D-0020, task orders 0002, 0006, 0007, 0010, and 0012. The technical editor was William J. Wolfe, Information Technology Laboratory. Larry M. Windingland is Chief, CEERD-CF-E, and L. Michael Golish is Chief, CEERD-CF. The associated Technical Director was Gary W. Schanche. The Acting Director of CERL is William D. Goran.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Director of ERDC is Dr. James R. Houston and the Commander is COL James S. Weller.

Contents

List of Figures and Tables

Figures

Tables

1 Introduction

Background

Fuel cells generate electricity through an electrochemical process that combines hydrogen and oxygen to generate direct current (DC) electricity. Fuel cells are an environmentally clean, quiet, and a highly efficient method for generating electricity and heat from natural gas and other fuels. Air emissions from fuel cells are so low that several Air Quality Management Districts in the United States have exempted fuel cells from requiring operating permits. Today's natural gas-fueled fuel cell power plants operate at electrical conversion efficiencies of 40 to 50 percent; these efficiencies are predicted to climb to 50 to 60 percent in the near future. In fact, if the heat from the fuel cell process is used in a cogeneration system, efficiencies can exceed 85 percent. By comparison, current conventional coal-based technologies operate at efficiencies of 33 to 35 percent.

Phosphoric Acid Fuel Cells (PAFCs) are in the initial stages of commercialization. While PAFCs are not now economically competitive with other more conventional energy production technologies, current cost projections predict that PAFC systems will become economically competitive within the next few years as market demand increases.

Fuel cell technology has been found suitable for a growing number of applications. The National Aeronautics and Space Administration (NASA) has used fuel cells for many years as the primary power source for space missions and currently uses fuel cells in the Space Shuttle program. Private corporations have recently been working on various approaches for developing fuel cells for stationary applications in the utility, industrial, and commercial markets. Researchers at the U.S. Army Engineer Research and Development Center (ERDC), Construction Engineering Research Laboratory (CERL) have actively participated in the development and application of advanced fuel cell technology since fiscal year 1993 (FY93), and have successfully executed several research and demonstration work units with a total funding of approximately $55M.

As of November 1997, 30 commercially available fuel cell power plants and their thermal interfaces have been installed at DoD locations, CERL managed 29 of these installations. As a consequence, the Department of Defense (DoD) is the owner of the largest fleet of fuel cells worldwide. CERL researchers have developed a methodology for selecting and evaluating application sites, have supervised the design and installation of fuel cells, and have actively monitored the operation and maintenance of fuel cells, and compiled "lessons learned" for feedback to manufacturers. This accumulated expertise and experience has enabled CERL to lead in the advancement of fuel cell technology through major efforts such as the DoD Fuel Cell Demonstration Program, the Climate Change Fuel Cell Program, research and development efforts aimed at fuel cell product improvement and cost reduction, and conferences and symposiums dedicated to the advancement of fuel cell technology and commercialization.

This report presents an overview of the information collected at 911th Airlift Wing, Pittsburgh, PA along with a conceptual fuel cell installation layout and description of potential benefits the technology can provide at that location. Similar summaries of the site evaluation surveys for the remaining 28 sites where CERL has managed and continues to monitor fuel cell installation and operation are available in the companion volumes to this report (see Table 1).

Objective

The objective of this work was to evaluate 911th Airlift Wing as a potential location for a fuel cell application.

Approach

On 27 and 28 March 1996, CERL and SAIC representatives visited the 911th Tactical Airlift Group (the site) to investigate it as a potential location for a 200 kW fuel cell. This report presents an overview of information collected at the site along with a conceptual fuel cell installation layout and description of potential benefits. The Appendix to this report contains a copy of the site evaluation form filled out at the site.

Table 1. Companion ERDC/CERL site evaluation reports.

Location	Report No.
Fort Bliss, TX	TR 01-13
Fort Eustis, VA	TR 00-17
Fort Huachuca, AZ	TR 00-14
Fort Richardson, AK	TR 00-Draft
Picatinny Arsenal, NJ	TR 00-24
Pine Bluff Arsenal, AR	TR 01-15
U.S. Army Soldier Systems Center, Natick, MA	TR 00-Draft
U.S. Military Academy, West Point, NY	TR 00-Draft
Watervliet Arsenal, Albany, NY	TR 00-Draft
911th Airlift Wing, Pittsburgh, PA	TR 00-18
934th Airlift Wing, Minneapolis, MN	TR 00-19
Barksdale Air Force Base (AFB), LA	TR 01-29
Davis-Monthan AFB, AZ	TR 00-23
Edwards AFB, CA	TR 00-Draft
Kirtland AFB, NM	TR 00-Draft
Laughlin AFB, TX	TR 00-Draft
Little Rock AFB, AR	TR 00-Draft
Nellis AFB, NV	TR 01-31
Westover Air Reserve Base (ARB), MA	TR 00-20
Construction Battalion Center (CBC) Port Hueneme, CA	TR 00-16
Naval Air Station Fallon, NV	TR 00-15
Naval Education Training Center, Newport, RI	TR 00-21
Naval Hospital, Marine Corps Base Camp Pendleton, CA	TR 00-Draft
Naval Hospital, Naval Air Station Jacksonville, FL	TR 01-30
Naval Oceanographic Office, John C. Stennis Space Center, MS	TR 01-3
Subase New London, Groton, CT	TR 00-Draft
U.S. Naval Academy, Annapolis, MD	TR 00-22
National Defense Center for Environmental Excellence, (NDCEE) Johnstown, PA	TR 01-33
Naval Hospital, Marine Corps Air Ground Combat Center (MCAGCC) Twentynine Palms, CA	TR 01-32

Units of Weight and Measure

U.S. standard units of measure are used throughout this report. A table of conversion factors for Standard International (SI) units is provided below.

1 ft	=	0.305 m
1 mile	=	1.61 km
1 acre	=	0.405 ha
1 gal	=	3.78 L
°F	=	°C (X 1.8) + 32

2 Site Description

The 911th Tactical Airlift Group (TAG) is located at the Pittsburgh International Airport in Pittsburgh, PA. The Site's primary function is to organize, train, and recruit Air Force Reservists to provide airlift of airborne forces and delivery of forces and supplies. Reserve personnel attend training sessions on weekends and/or various weeks throughout the year. The 911th TAG also serves as a processing center for new recruits.

The dining hall building (building 213) was identified as the best candidate application at the 911th TAG location for a 200 kW fuel cell. Building 213 houses the dining hall and a boiler facility, which provides heat to the dining hall and seven surrounding barracks buildings. The boiler provides 190 °F hot water to a distribution system. Space heating is provided by the boiler from October 15th through May 15th. Outdoor temperatures range from 1 °F to 100 °F throughout the year. Occupancy at the dormitory buildings is about 50 percent annually. Each month, there are roughly three training weekends where occupancy reaches 70, 90, and 100 percent.

Three of the barracks buildings are scheduled to be demolished in 1999 and replaced with a single new building in the year 2000. The new building will house both offices and accommodations for Reserve personnel.

Site Layout

Figure 1 presents an overview of building 213 and the surrounding buildings. The four buildings to the south (buildings 216-219) are barracks that are occupied at about a 50 percent occupancy. The three buildings to the north (buildings 208-210) will be torn down in 1999 and replaced by a single, larger building that will house both offices and dormitory space.

The boiler is located in the east end of building 213 and has two primary loops (north and south) that provide heating to the outlying buildings. There are also old domestic hot water (DHW) pipes that were recently capped off that used to supply DHW to the individual buildings. Presently, instantaneous hot water heaters and 200-gal DHW tanks are located in each building.

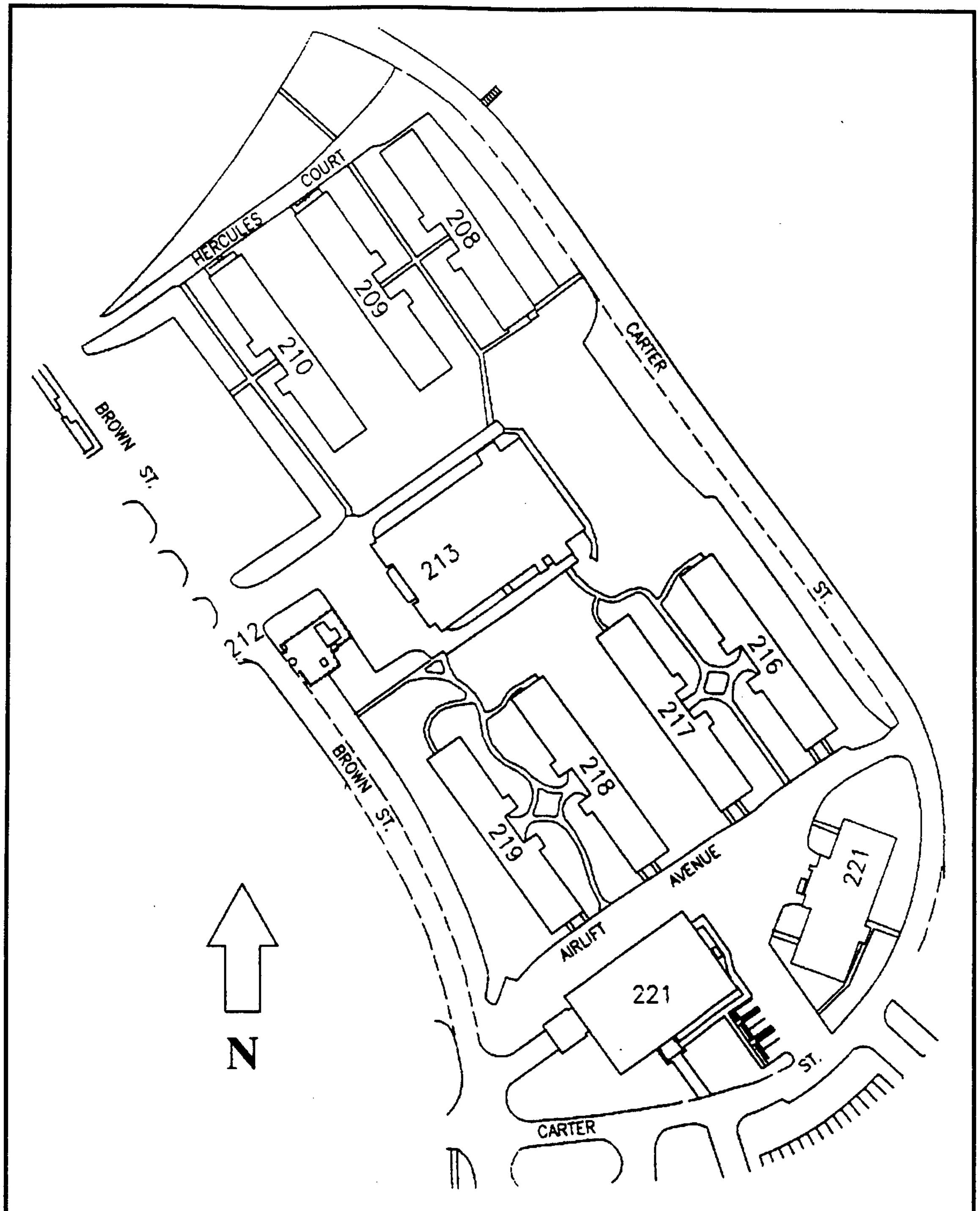

Figure 1. 911th TAG Dining Hall/Boiler Plant layout with adjacent buildings.

There is a 100 kW natural gas fired reciprocating generator located on the south side of the building that provides backup power to the dining hall. In total, there are 10 backup generators at the 911th TAG ranging in size from 60 kW to 155 kW and totaling 848 kW.

There are natural gas and electrical tie ins located on the south side of the dining hall. The main electrical yard for the entire base is located on the west side of the dining hall in building 212.

Electrical System

The base receives electrical power from Duquesne Light at building 212 and then distributes throughout the base at 4160 volts. Most of the power at the dining hall is at 120/208 volt. There is one 480 volt transformer for the building, but is only rated at 225 kVA. The fuel cell requires a minimum 300 kVA transformer. An intermediate transformer would be required for integrating the fuel cell at this location.

Steam/Hot Water System

The dining hall houses the boiler system that provides heat to building 213 and the seven surrounding buildings. The boiler is an H.B. Smith Series M450L-W-16 having a maximum input fuel rate of 6,545 kBtu/hr and a rated efficiency of approximately 70 percent. The maximum hot water pressure rating of the system is 40 psi. The boiler operates on natural gas and has a temperature set point of approximately 190 °F. Hot water is sent from the boiler to two feeders that supply the three north buildings and the four south buildings.

Space Heating System

Individual rooms are maintained at about 70 °F throughout the heating season. There is no temperature set-back when unoccupied. The hot water for space heating is provided from the dining hall boiler via the underground distribution system.

Space Cooling System

The dining hall has rooftop air conditioning units. Five of the surrounding buildings (buildings 210, 216-219) have 25 ton Trane chillers. A sixth 25 ton chiller is planned for building 209 for fall installation.

Fuel Cell Location

The fuel cell should be located on the south side of the dining hall as shown in Figure 2. The fuel cell should run east-west parallel to the long side of the building next to the existing sidewalk. The thermal output connections on the fuel cell should face towards the dining hall building. The thermal piping run will be approximately 90 ft and the electrical run will be 20 ft. The natural gas piping will be approximately 15 ft to the nearest point on the existing gas line.

Fuel Cell Interfaces

Electricity is supplied to the dormitories (Buildings 216-219) through a four way switch (switch "D") located between building 213 and building 218. Power is supplied through the switch at 4160 volts and is transformed to 208 volts at each dormitory. The fuel cell electrical output will be connected to the existing spare location on switch "D." A new pad mounted transformer rated at a minimum of 300 kVA is required.

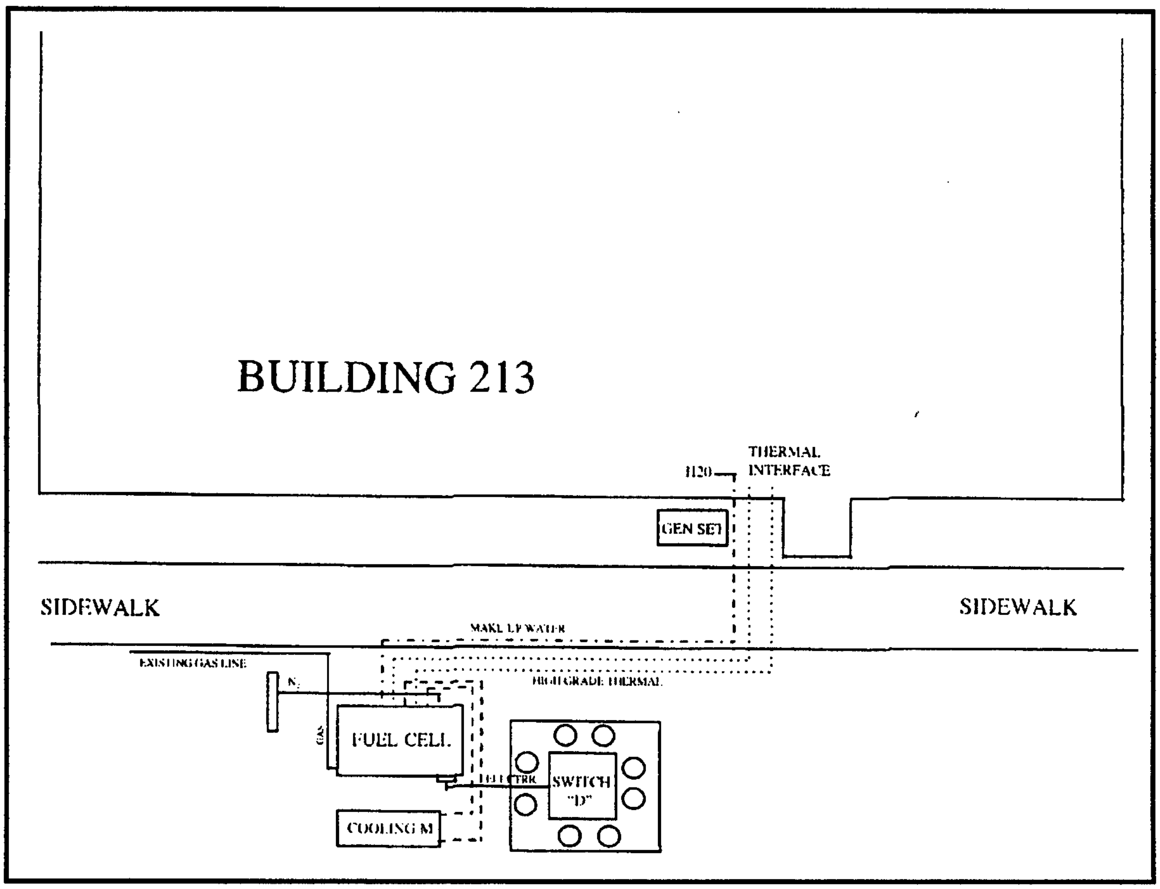

Figure 2. Fuel cell location and layout.

Table 2. Monthly boiler gas consumption.

Month	Gas Use (MCF)	Average Load (KBtu/hr)**	Minimum Load (KBtu/hr)
October - 94*	325	651	202
November - 94	514	515	159
December - 94	735	712	477
January - 95	1060	1027	688
February - 95	1094	1173	786
March -95	591	573	178
April - 95	490	384	119
May - 95*	121	242	75

* Space Heating = 15 days/month
**Avg. Load = (MCF gas use * 1030 kBtu/MCF * 0.70 boiler efficiency) / (hr/month)

Based on the electrical load profile data provided by the site (see attached site evaluation form), the minimum electric load for the entire base is approximately 310 kW. This indicates that all of the fuel cell electrical output will be utilized on site and that there will be no sell back to the utility grid. As part of the detailed design process, a protective relay might be considered in cases of extremely low load at the base while the fuel cell is operating.

Currently, the only applicable thermal load for the fuel cell is to provide heat to the hydronic space heating system that now supplies space heating for buildings 208-210, 213, and 216-219. Domestic hot water is supplied by instantaneous gas fired water heaters and storage tanks in each building. A central DHW loop was previously decommissioned due to the age of pipes. Integrating the surrounding buildings' DHW load with the fuel cell would require extensive repiping.

For the fuel cell to interface with the current space heating system, the high grade heat exchanger option for the fuel cell would be required. The hydronic space heating system supplies approximately 190 °F water to individual room fan coil units and returns approximately 170 °F water to the boiler. This return temperature is hotter than the standard fuel cell heat exchanger can supply (up to about 150 °F). The high grade heat exchanger option can supply up to 250 °F water, which is compatible with the hydronic space heat loop. The space heating load was determined from the gas meter logs for the boiler. Table 2 lists the monthly boiler gas consumption.

The minimum loads listed above were estimated based on measured space heating load profile data, cf. Science Applications International Corporation, *Characterization of Instrumented Sites for the Onsite Fuel Cell Field Test Project, Volume 1*, Gas Research Institute, Report No. 86/0292.1 (November 1986.). In the cool months (October, November, March, April, May) it was estimated that the minimum load was 31 percent of the average space heating load. It was also estimated from the measured load profile data that on a typical day the space heating load was at the minimum for about 9.5 hr or 40 percent of the hours in a day. During the cold months (December - February), the minimum load was estimated to be 65 percent of the average load. The minimum load during the cold months was above the output of the fuel cell (>350,000 Btu/hr) and, therefore, 100 percent of the fuel cell output could be used. Table 3 lists the thermal utilization for this site.

Table 3. Thermal utilization for the 911 Airlift Wing.

Month	Percent Utilization*	Heat Utilized (Mbtu)
Oct 94*	83%	105
Nov 94	78%	197
Dec 94	100%	260
Jan 95	100%	260
Feb 95	100%	235
Mar 95	80%	208
Apr 95	74%	186
May 95*	68%	86
Ave/Total	85%	1537

* Based on 350 KBtu/hr available for seven months.

Based on the space heating load profile data and gas consumption data, an estimated 3,000-gal storage tank would be required to increase the thermal utilization from 85 to 100 percent of the 350 kBtu/hr available for the 7-month heating season. Figure 3 shows an assumed load profile for storage size.

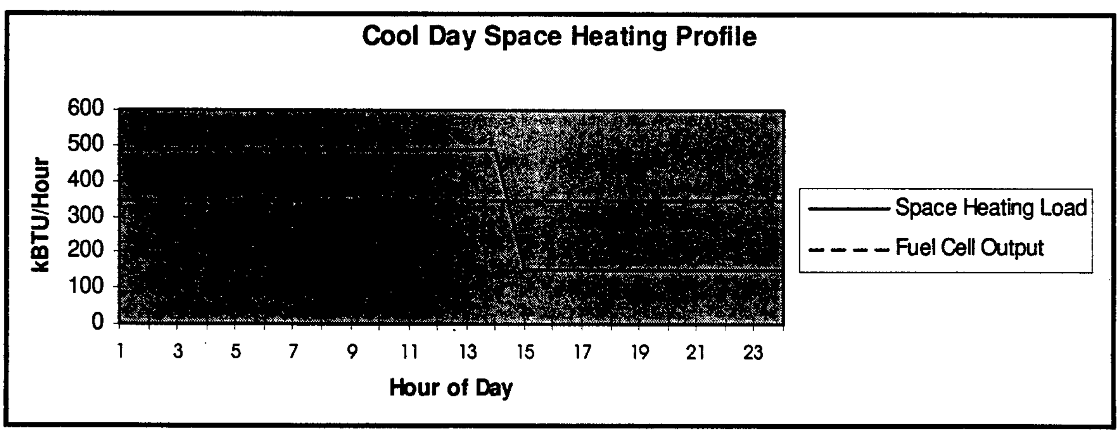

Figure 3. Assumed load profile for storage size.

The available fuel cell heat for charging storage would be:

1,900 kBtu/day = (350 kBtu/hr - 150 kBtu/hr) * 9.5 hr/day.

The required heat from the storage tank would be:

2,030 kBtu/day = (490 kBtu/hr - 350 kBtu/ hr) * 14.5 hr /day.

The storage size would be:

3,039 gal = about 2,030 kBtu/day / (250 °F-170 °F) (8.35 lb/gal) (1 Btu/ °F-lb.)

This sizing is based on the required heat for an average "cool" day. This slightly conservative sizing is recommended to fully utilize the fuel cell heat.

A potential future thermal interface for the fuel cell is the domestic hot water for the new building planned for completion in the year 2000 which will replace buildings 208-210 as well as the BOQ which will be moved from building 206. The domestic hot water interface could utilize the standard, low-grade fuel cell heat exchanger. A rough estimate of this potential load was calculated using the ASHRAE estimate of 13.1 gal of hot water per person per day. There will be approximately 108 rooms in the new building. Assuming an average annual occupancy rate of 50 percent (current occupancy rate at the base) and 140 °F supply and 60 °F make-up water temperatures, the estimated DHW load for the new building is:

19.7 KBtu/ hr = (13.1 gal/day * 108 rooms * 50% occupancy * 8.35 lb/gal * 1 Btu/ °F-lb * (140 °F-60 °F)) /(24 hr per day).

The recommended thermal interface is shown in Figure 4. The fuel cell's high grade heat exchanger should be tied into the space heating return line from buildings 216-219. An additional circulation pump should be used to pull the recommended heat exchanger flow through the fuel cell. This will allow the design flow rate to go to the fuel cell without restricting the space heating water flow. The pump should be activated whenever the main circulating pumps are running and the fuel cell is operating. The pump should shut off when the mix temperature at the discharge from the circulating pumps reaches the maximum desired temperature, about 190 °F.

Figure 5 presents the conceptual thermal interface design for the storage case. Return water will flow into a pressurized 3,000 gal storage tank. The storage tank will be heated up to 250 °F by the fuel cell and the outlet will be mixed with the return water to provide a temperature of 190 °F at the pump discharge.

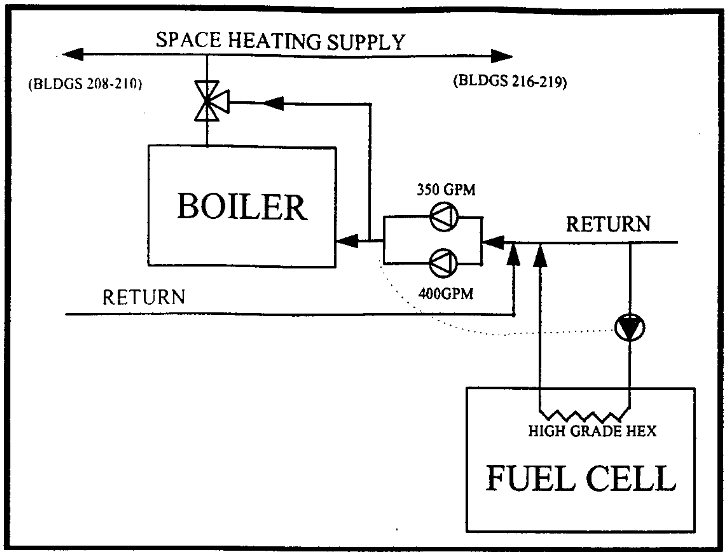

Figure 4. Fuel cell thermal interface – space heat.

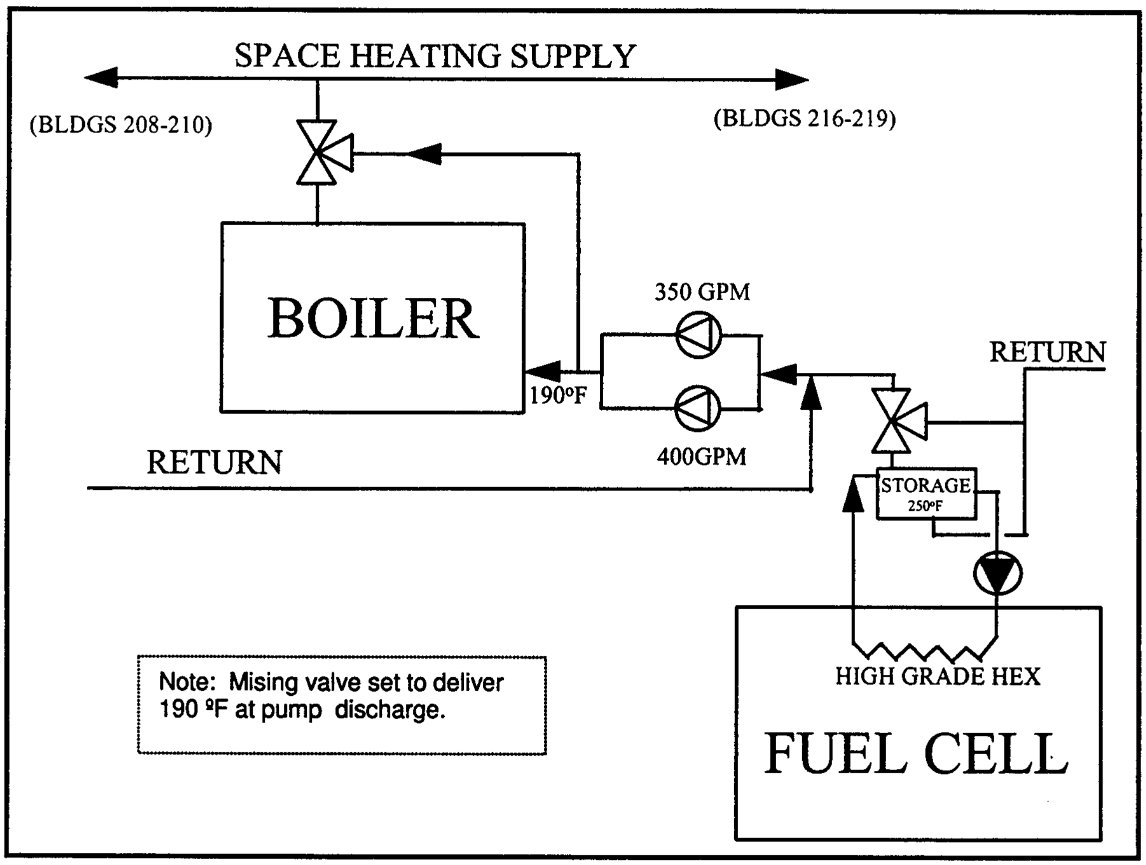

Figure 5. Fuel cell thermal interface with storage – space heat.

3 Economic Analysis

The 911th TAG is located in Duquesne Light's service territory and billed under GL - General Service Large electric rate schedule. The Site pays $18.55/kW for the first 300 kW of demand and then $14.08/kW for monthly demand exceeding 300 kW. The energy charge is 3.83 cents/kWh. Historical records show that an "energy cost rate" credit of 0.2415 to 0.2433 cents/kWh is given to the base lowering their average energy charge to approximately 3.59 cents/kWh. On-peak and off-peak demand is measured, but a separate rate is not applied. Table 4 lists the electric bills for the Site during FY95. An overall annual average of 7.37 cents/kWh was paid for electricity (includes both demand and energy charges).

Natural gas is purchased from Peoples Gas. Table 5 summarizes the Site's FY95 gas bill. An average gas cost of $6.40/MCF was paid in FY95 and ranged from a low of $6.05/MCF in April-95 to a high of $7.48/MCF in July-95. The average variances are due to fixed charges and differences in monthly consumption. The Site pays a flat rate per MCF negotiated on an annual basis in addition to the fixed charges. In FY96, the negotiated rate is approximately $4.82/MCF.

A preliminary inquiry to Peoples Gas by the Site revealed that a lower gas rate might be obtained for the fuel cell input fuel. Peoples Gas quoted a rate of $3.75/MCF. This rate was used for the Base Case to estimate potential fuel cell savings. Another case using the boiler gas rate ($4.82/MCF) was also evaluated.

Table 4. 911th TAG FY95 electric bills.

Month	KW	KWH	Total	$/KWH
Oct-94	1,220	406,800	$33,080	$0.0813
Nov-94	910	388,800	$28,080	$0.0722
Dec-94	940	409,200	$29,181	$0.0713
Jan-95	1,001	451,200	$31,592	$0.0700
Feb-95	999	429,600	$31,108	$0.0724
Mar-95	998	454,800	$31,681	$0.0697
Apr-95	949	382,800	$28,404	$0.0742
May-95	886	372,000	$27,045	$0.0727
Jun-95	1,125	408,000	$31,683	$0.0777
Jul-95	1,273	451,200	$35,307	$0.0783
Aug-95	1,270	495,600	$36,713	$0.0741
Sep-95	1,269	525,600	$37,713	$0.0718
Tot/Avg	1,070	5,175,600	$381,586	$0.0737

Table 5. 911th TAG FY95 natural gas bills.

Month	MCF	Total	$/MCF
Oct-94	1,646	$10,580	$6.43
Nov-94	2,930	$18,582	$6.34
Dec-94	4,473	$28,725	$6.42
Jan-95	5,796	$36,968	$6.38
Feb-95	5,580	$35,335	$6.33
Mar-95	3,606	$23,948	$6.64
Apr-95	2,953	$17,853	$6.05
May-95	853	$5,375	$6.30
Jun-95	218	$1,613	$7.40
Jul-95	210	$1,571	$7.48
Aug-95	227	$1,652	$7.28
Sep-95	247	$1,727	$6.99
Tot/Avg	28,739	$183,929	$6.40

Electric savings from the fuel cell were calculated based on the fuel cell operating 90 percent of the year (1,576,800 kWh). A range of fuel cell demand savings was also calculated. Table 6 shows the results of this analysis. Assuming full demand savings by the fuel cell (i.e., 200 kW/month) and a 90 percent capacity factor for the fuel cell, the fuel cell could generate $56,607 in energy savings and $33,792 in demand savings for a total electric savings of $90,399.

Thermal savings were estimated based on the 1,537 MBtu calculated for the seven heating months. This was adjusted downward for a 90 percent fuel cell capacity factor. An annual thermal utilization for the high grade heat exchanger of 50 percent was calculated:

50% = (1,537 MBtu/yr * 90%) / (0.35 MBtu/hr * 8,760 hr/yr * 90%)

This is equivalent to an overall fuel cell thermal utilization of 25 percent based on a thermal output rating of 700,000 Btu/hr from the fuel cell. Using a displaced boiler efficiency of 70 percent, the fuel cell could displace 1,976 MBtu of natural gas. Based on an average natural gas rate of $4.96/MBtu ($4.82/MCF * 1.03 MBtu/MCF), thermal savings from the fuel cell would be $9,801.

The value of displacing the DHW load in the new building was also calculated. Using an average of 19.7 kBtu/hr, the displaced thermal is calculated as:

221 MBtu = (.0197 MBtu/hr * 8,760 hrs/yr * 90% cap. factor) / (70% boiler eff.)

Savings from displacing the new building DHW load would be $1,096 (221 MBtu/yr * $4.96/MBtu). This increases the annual thermal utilization from 25 to 29 percent.

The natural gas cost for the fuel cell was assumed to be $3.86/MBtu ($3.75/MCF * 1.03 MBtu/MCF). The fuel cell will consume 14,949 MBtu the first year based on an electrical efficiency of 36 percent HHV. Input natural gas cost for the fuel cell is $57,703.

The net savings for the base case of full demand savings and 25 percent annual thermal utilization case (high grade heat exchanger) is $42,497 as shown in Table 6. Increasing the thermal utilization to 29 percent for the new building DHW load increased the net savings to $43,593. Using the boiler gas rate for base case fuel cell input fuel lowered the net savings to $26,053.

The impact of thermal storage on net savings is $1,657. The total cost of installing a 3,000 gal pressurized storage tank plus the mixing valve and pad is estimated at $8,000, resulting in a pay back period of 4.8 years.

The analysis is a general overview of the potential savings from the fuel cell. For the first 3 years, ONSI will be responsible for the fuel cell maintenance. Maintenance costs are not reflected in this analysis, but could represent a significant impact on net energy savings. Since detailed load energy profiles were not available, net energy savings could vary depending on actual thermal and electrical utilization.

Table 6. Economic savings of fuel cell design alternatives.

Case	ECF	TU*		Displaced kWh	Displaced Gas (MBtu	Electrical Savings	Thermal Savings	Nat. Gas Cost	Net Savings
A – Max. Thermal	90%		100%	1,576,800	7,884	$90,399	$39,105	$57,703	$71,801
A – Base Case + DHW Load	90%	29%	(58%)	1,576,800	2,197	$90,399	$10,897	$57,703	$43,593
A – Base Case + Storage	90%	29%	(58%)	1,576,800	2,310	$90,399	$11,458	$57,703	$44,154
A – Base Case	90%	25%	(50%)	1,576,800	1,976	$90,399	$9,801	$57,703	$42,497
A – Base Case wl$4.96 Gas	90%	25%	(50%)	1,576,800	1,976	$90,399	$9,801	$74,147	$26,053
B – Max. Thermal	90%		100%	1,576,800	7,884	$73,503	$39,105	$57,703	$54,905
B – Base Case + DHW Load	90%	29%	(58%)	1,576,800	2,197	$73,503	$10,897	$57,703	$26,697
B – Base Case + Storage	90%	29%	(58%)	1,576,800	2,310	$73,503	$11,458	$57,703	$27,258
B – Base Case	90%	25%	(50%)	1,576,800	1,976	$73,503	$9,801	$57,703	$25,601
B – Base Case w/$4.96 Gas	90%	25%	(50%)	1,576,800	1,976	$73,503	$9,801	$74,147	$9,157
C – Max. Thermal	90%		100%	1,576,800	7,884	$56,607	$39,105	$57,703	$38,009
C – Base Case + DHW Load	90%	29%	(58%)	1,576,800	2,197	$56,607	$10,897	$57,703	$9,801
C – Base Case + Storage	90%	29%	(58%)	1,576,800	2,310	$56,607	$11,458	$57,703	$10,362
C – Base Case	90%	25%	(50%)	1,576,800	1,976	$56,607	$9,801	$57,703	$8,705
C – Base Case w/$4.96 Gas	90%	25%	(50%)	1,576,800	1,976	$56,607	$9,801	$74,147	($7,739)

Assumptions:

Input Natural Gas Rate: $3.86 /MBtu
Displaced Thermal Gas Rate: $4.96 /MBtu
Fuel Cell Thermal Output: 350,000 Btu / hr
Fuel Cell Electrical Efficiency: 36%
Seasonal Boiler Efficiency: 70%

CASE A: full fuel cell demand savings
CASE B: 50% of full fuel cell demand savings
CASE C: zero fuel cell demand savings
ECF Fuel cell electric capacity factor

TU = Thermal utilization using both high and low grade heat exchangers as basis (using only high grade heat exchanger as base)

4 Conclusions and Recommendations

This study concludes that the dining hall/boiler facility and seven surrounding buildings represent a good application for the 200 kW ONSI PC25C fuel cell. Net first year savings are approximately $42,500 to $44,000 (depending if storage is used) with full demand savings and the new lower quoted gas rate of $3.75/MCF. It is important for the Site to secure the reduced gas rate ($3.75/MCF vs. $4.82/MCF) as it adds an additional $16,000/year in net savings.

The proposed location of the fuel cell between buildings 213 and 218 provides ample space and access for the fuel cell. The electrical, thermal and gas runs are relatively short and the interfaces straightforward. A new 4160/480 volt transformer will be required. The thermal interface with the space heating system provides a very good application for the high grade heat exchanger option which has yet to be demonstrated.

Appendix: Fuel Cell Site Evaluation Form

Site Name: **911th Tactical Airlift Group**

Location: **Pittsburgh, PA**

Contacts: **Bruce Foster**

1. Electric Utility: Duquesne Light

   Contact: **N/A**

   Rate Schedule: **GL- General Service Large**

2. Gas Utility: **Peoples Gas**

   Rate Schedule:
   Contact: **N/A**

3. Available Fuels: **Natural Gas, Fuel Oil**

   Capacity Rate:

4. Hours of Use and Percent Occupied: **50% occupancy in dormitory**

   Weekdays ______ Hrs.________
   Saturday ______ Hrs.________
   Sunday ______ Hrs.________

5. Outdoor Temperature Range: **1 - 89 ºF**

6. Environmental Issues: **Pittsburgh is not a non-attainment area; permitting not at problem.**

7. Backup Power Need/Requirement: **Ten backup generators on base. 100 kW unit at Dining Hall facility.**

8. Utility Interconnect/Power Quality Issues: **None.**

9. On-site Personnel Capabilities: **Boiler plant personnel at facility.**

10. Access for Fuel Cell Installation: **Accessible – slight hill where fuel cell to be sited.**

11. Daily Load Profile Availability: **Sample load profiles supplied by site. Attached.**

12. Security: **No fence needed. Site will install appropriate landscaping.**

Site Layout

Facility Type: **Dining Hall/Boiler Facility** Age: **>30 years**

Construction: **Concrete block**

Square Feet: **16,000 sq ft (100 X 160 ft)**

See Figure 1

Show:

- electrical/thermal/gas/water interfaces and length of runs
- drainage
- building/fuel cell site dimensions
- ground obstructions

Electrical System

Service Rating: **4,160 volt service to building 480 and 120/208 volt service in building**

Electrically Sensitive Equipment: **None**

Largest Motors (hp, usage):

Grid Independent Operation?: **No**

Steam/Hot Water System

Description: **H. B. Smith Series M450L-W-16.**

System Specifications: **Max pressure 40 psi.**

Fuel Type: **Natural Gas.**

Max Fuel Rate: **6,545 kBtu input.**

Storage Capacity/Type: **None.**

Interface Pipe Size/Description: **6 in. to buildings.**

End Use Description/Profile: **Hot water delivered to Dining Hall and 7 surrounding buildings for space heating.**

Space Cooling System

Description: **Rooftop units on Dining Hall; individual chillers at dormitories.**

Air Conditioning Configuration:
Type: **Trane chillers.**
Rating: **25 Ton.**
Make/Model:

Seasonality Profile: **Chillers operate infrequently through summer months.**

Space Heating System

Description: **Provided by central boiler.**

Fuel: **Natural Gas.**

Rating: **6,545 kBtu input fuel.**

Water supply Temp: **180 °F.**

Water Return Temp: **160 °F.**

Make/Model: **Fan coil units.**

Thermal Storage (space?): **None.**

Seasonality Profile: **7 months - October 15 through May 15.**

Billing Data Summary

ELECTRICITY

Period	kWh	kW	Cost
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10			
11.			
12.			

NATURAL GAS

Period	Consumption	Cost
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10		
11.		
12.		

OTHER

Period	Consumption	Cost
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10		
11.		
12.		

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14. ABSTRACT

Fuel cells are an environmentally clean, quiet, and a highly efficient method for generating electricity and heat from natural gas and other fuels. Researchers at the U.S. Army Engineer Research and Development Center (ERDC), Construction Engineering Research Laboratory (CERL) have actively participated in the development and application of advanced fuel cell technology since fiscal year 1993 (FY93). CERL has selected and evaluated application sites, supervised the design and installation of fuel cells, actively monitored the operation and maintenance of fuel cells, and compiled "lessons learned" for feedback to manufacturers for 29 of 30 commercially available fuel cell power plants and their thermal interfaces installed at Department of Defense (DoD) locations.

This report presents an overview of the information collected at the 911th Airlift Wing, Pittsburgh, PA, along with a conceptual fuel cell installation layout and description of potential benefits the technology can provide at that location. Similar summaries of the site evaluation surveys for the remaining 28 sites where CERL has managed and continues to monitor fuel cell installation and operation are available in the companion volumes to this report.

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energy conservation
911th Airlift wing, Pittsburgh, PA

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